*Review Draft*

# Solar Siting Methodology for State and Local Governments

## Pilot:Baltimore County and City

Prepared for the Valleys Planning Council

by Susan Minnemeyer and Emily Wiggans
Chesapeake Conservancy
Conservation Innovation Center

June 2020

# Table of Contents

## Summary

Maryland's updated Renewable Portfolio Standard will require 50 percent of electricity to be generated from renewable sources by 2030, with a 14.5% carve-out for solar energy. The Power Plant Research Program report on the RPS standard projects 9,000 GWh, or 8,946 MW of installed solar capacity, will be required to come from solar energy generation by 2028, from a mix of residential, commercial, community and utility-scale sources. Maryland's current solar capacity stands at 1,250 MW, or enough energy to generate 1,258 GWh of energy annually, about 14% of the goal to be reached by 2028. Baltimore city and County could potentially contribute a significant share of the area needed to scale up solar, but where?

In the absence of incentives for siting elsewhere, prime agricultural farmland will likely be the key land use occupied by future solar arrays, compounding the loss of farmland to residential and commercial development and the stresses on food production likely to come with climate change.

To produce the additional solar energy capacity needed in less than a decade, utility-scale solar promises potential to scale up quickly, at the lowest cost compared to other options. But to meet the full range of potential benefits from solar energy and to avoid environmental tradeoffs, maximizing the amount of solar in the built environment can achieve renewable energy goals with the fewest adverse impacts, while also providing the greatest amount of jobs and the opportunity for more residents to access the economic benefits of solar energy. Ground-mounted solar on preferred sites, that avoids prime farmland, forested areas and ecologically valuable areas can also contribute to rapid solar expansion.

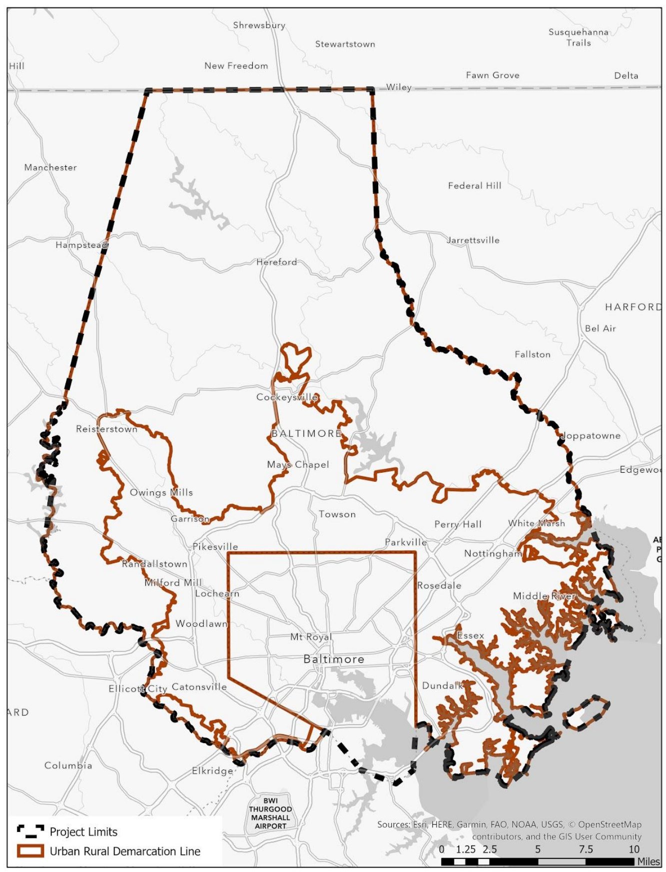
[Add statement on importance of prime farmland for food production; prime farmland required for healthy soil and future}

Baltimore city and County offer over 31,000 acres of optimal and preferred solar sites, enough area to generate over 12,000 GWh/year of electricity from solar energy, which would exceed the statewide solar carve-out goal by 25%. The majority of this area, 86%, is in developed areas, on residential and commercial rooftops (70%) and in the largest parking lots (16%). Degraded lands provide an additional 1,100 acres of optimal solar energy sites (3.5%), while preferred areas for ground-mounted solar panels provide and additional 3,400 acres (11%). Policies and incentives that would guide solar energy development towards these optimal and preferred solar sites could ensure solar energy expansion provides the greatest possible benefits for Maryland's citizens.

# Introduction

Maryland’s new Renewable Portfolio Standard, established as part of the Clean Energy Jobs Act in 2019, will require 14.5% of electricity generation to come from solar, of 50% from renewable energy sources by 2030.[1] Our objective in this study is to identify suitable locations for solar energy development, while avoiding undesirable environmental tradeoffs. We approached this objective with a high-resolution geospatial analysis of criteria for optimal and preferred solar siting for Baltimore City and County (Figure 1, map at right below) and measure developable area to determine potential renewable energy generation. This approach may be used by decision makers to evaluate solar energy development proposals and to develop incentives to encourage development in preferred locations. Our study followed these principles:

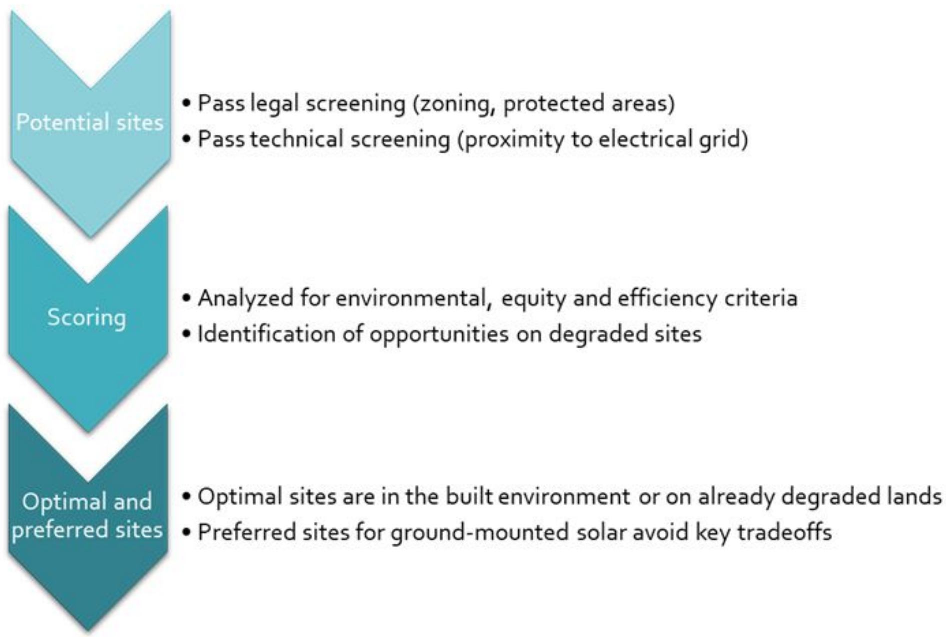
- Solar energy development is critical to meeting Maryland’s renewable energy goals.
- Careful siting of solar development can maximize benefits and reduce adverse impacts.
- Solar development should avoid adverse environmental impacts wherever possible by making the most of opportunities on already developed or degraded lands.
- Consideration of equity and opportunity will help ensure solar energy benefits are available to all residents.
- Our analysis is not intended to be exhaustive of all criteria used to select sites and further screening will be needed. Policies or incentives may be required to guide solar development to preferred sites.




[1] "Maryland bill mandating 50% renewable energy by 2030 to become ...." 22 May. 2019, https://www.baltimoresun.com/news/maryland/environment/bs-md-renewable-energy-law-20190522-story.html. Accessed 28 May. 2019.

Our approach to determine optimal solar siting involves first identifying potential solar sites, those that meet both legal and technical criteria for allowing solar energy development, and then evaluating potential solar sites on a range of environmental, equity, and efficiency criteria to determine optimal siting (Figure 2). We obtained geospatial data from a variety of sources - notably the Baltimore County and City data portals, the Maryland Departments of Natural Resource (DNR), Planning (MDP), Environment (MDE), the Power Plant Research Program's SmartDG+ planning tool, and the Maryland iMap data collection. Potential solar energy development sites for our study area were identified using zoning data along with screening layers of protected areas, easements and other areas where solar development would not be permitted. We also screened out ecologically important areas such as Marylands' Targeted Ecological Areas identified by the state as being high conservation priority areas.

**Figure 2. Approach for identifying optimal and preferred sites for solar energy development**




Next, for parcels over 5 acres in size, we overlaid potential solar sites with Chesapeake Conservancy's high resolution (1 meter) land cover data and the USDA's soil survey data to generate metrics for each parcel on land area composition for tree canopy cover, non-forest vegetation cover, prime farmland, and non-prime soils. We ranked parcels by their available solar opportunity area (SOA) or amount of land available in the parcel without either prime farm soils or tree cover. We also calculated building footprint area and the amount of impervious surface area along with city and county parking lot data to identify parcels with large opportunities for rooftop or parking canopy solar. For properties smaller than 5 acres we combined parcels by zoning category (residential, residential multifamily, commercial, industrial, mixed use, and resource conservation) to identify total rooftop and parking canopy area opportunity by zone.

We evaluated opportunities on degraded sites including landfills, Voluntary Cleanup Program (VCP) sites, underutilized industrial sites and other contaminated or underutilized or abandoned sites by collecting data on relevant properties in consultation with city and county planning and GIS staff. In addition we considered some special classes of properties including public buildings such as schools, firehouses, and other public properties where this information was available.

Results were tallied into three categories considered optimal siting opportunities: degraded lands, parking canopy and rooftop. Land parcels, not on degraded sites, over 5 acres in size that offered significant solar opportunity area (SOA) that was not on prime farmland or forest were considered “preferred ground-mounted sites.” These areas did not meet the criteria for optimal sites, but offer large size suitable for utility-scale solar while avoiding most adverse environmental impacts. Finally, we developed metrics for each category of optimal and preferred sites for solar energy capacity, measured in megawatts (MW) and annual energy generation in gigawatt hours per year (GWh/yr) to evaluate the ability for Maryland state and regional governments to meet solar energy requirements through development on optimal and preferred sites to meet the state’s Renewable Portfolio Standard goals for solar energy.

## Challenges for scaling solar energy generation

Improving affordability, advances in technological efficiency, and a wide array of federal, state and local incentives have led to rapid growth in installed solar capacity across Maryland. Solar installations range in size from small-scale residential and community rooftop systems, to small and large large rooftop commercial installations, large community ground-mounted systems, and utility-scale large solar PV facilities, which operate as power plants. Residential and commercial installations are typically “behind the meter” (BTM) resources, while larger community and utility-scale solar resources connect directly to the grid.[2]

According to the US Energy Information Administration, utility-scale solar in Maryland generated 448 thousand MWh in 2018 out of total net electricity generation in Maryland of 34.1 million MWh, or 1.3% (Figure 1), but the amount of energy from utility-scale solar is growing rapidly (Figure 2). A cost-benefit analysis of solar energy in Maryland assumed an additional 2.4 GW of solar energy resources will be installed between 2019 and 2028 and projects this growth will generate over $7 billion in economic returns to the state.

[2] "Benefits and Costs of Utility Scale and Behind the Meter Solar Resources in Maryland" 2 Nov. 2018, https://cleantechnica.com/files/2018/11/MDVoSReportFinal11-2-2018.pdf. Accessed 30 May. 2019.

**Figure 3. Maryland annual net generation for electric power, all major sources**

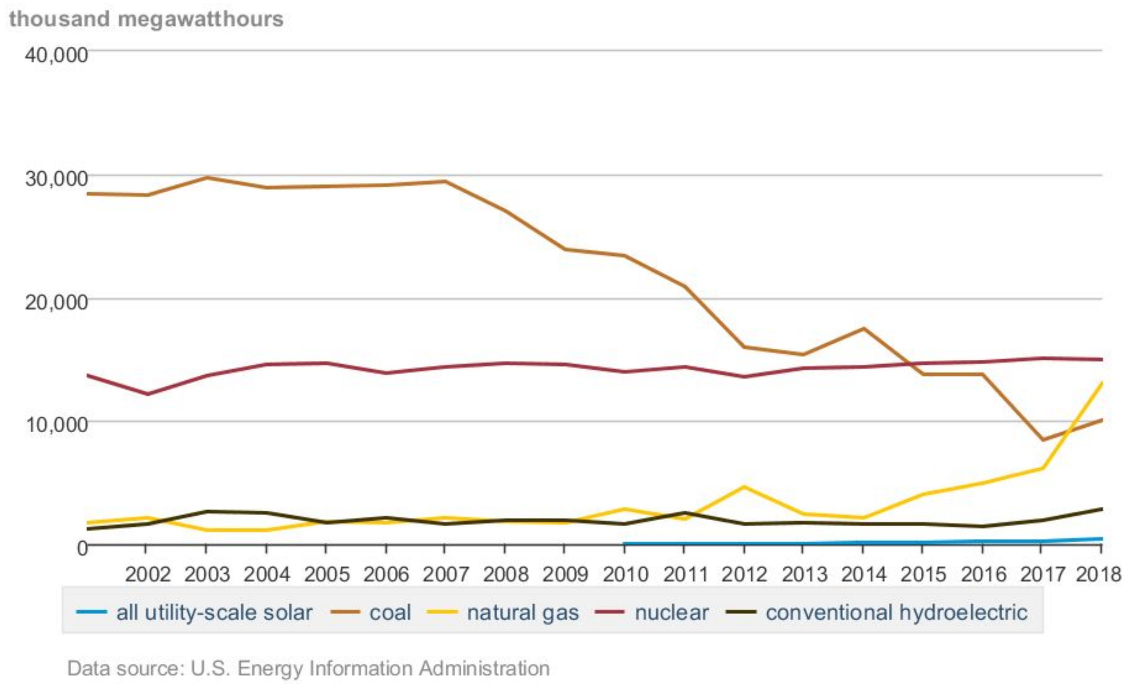
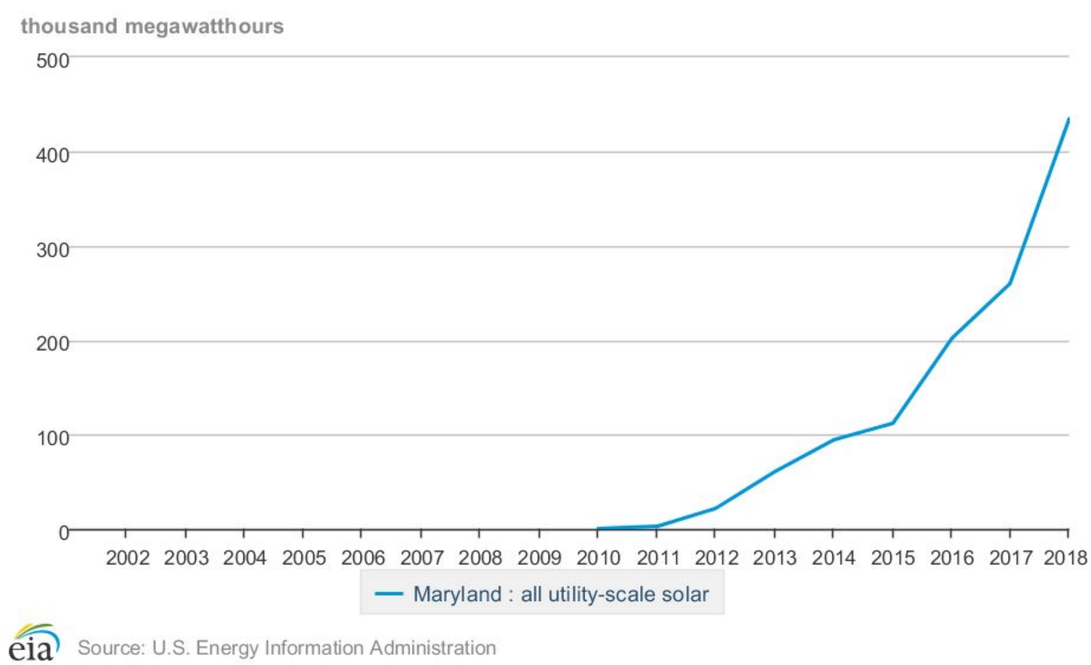



**Figure 4. Maryland annual net generation for electric power from utility-scale solar**




To meet the goals of Maryland's RPS standard, it is estimated that the 14.5% solar carve-out would require 9,000 GWh of electricity to be generated state-wide by solar (Figure 6), starting in 2028. To set a goal for this study, we estimated the share of future solar energy generation that would be needed to meet the RPS goals for Baltimore (city) and County by three methods - by electricity consumption, by land area, and by population.  The combined energy generation that would be required for the combined area ranged from a low of 619.8 GWh, when calculated as a portion of land area, to 2131.2, when calculated as a portion of population. We chose to use energy consumption as the prospective goal for the desirable amount of solar energy generation opportunities for our study area, to identify enough optimal locations to generate at least 1,967 GWh of electricity. However, there is no requirement that solar development to meet the RPS be distributed by any of these methods.

**Table 1. Baltimore City and County share of solar carve out calculated as share of Maryland total by electricity consumption (the method chosen for study goals), land area, and population**

**Electricity consumption (EIA, BGE)**

| | Consumption (GWh) | % of state consumption | Solar carve-out share (GWh) |
|---|---|---|---|
| **Baltimore city** | 6,271.54 | 10.1% | 909.1 |
| **Baltimore County** | 7,295.49 | 11.8% | 1,057.5 |
| **Baltimore - city and county combined** | 13,567.03 | 21.9% | **1,966.7** |
| **Maryland** | 62,086.46 | 100.0% | 9,000.0 |

**Land Area (MD Geological Survey)**

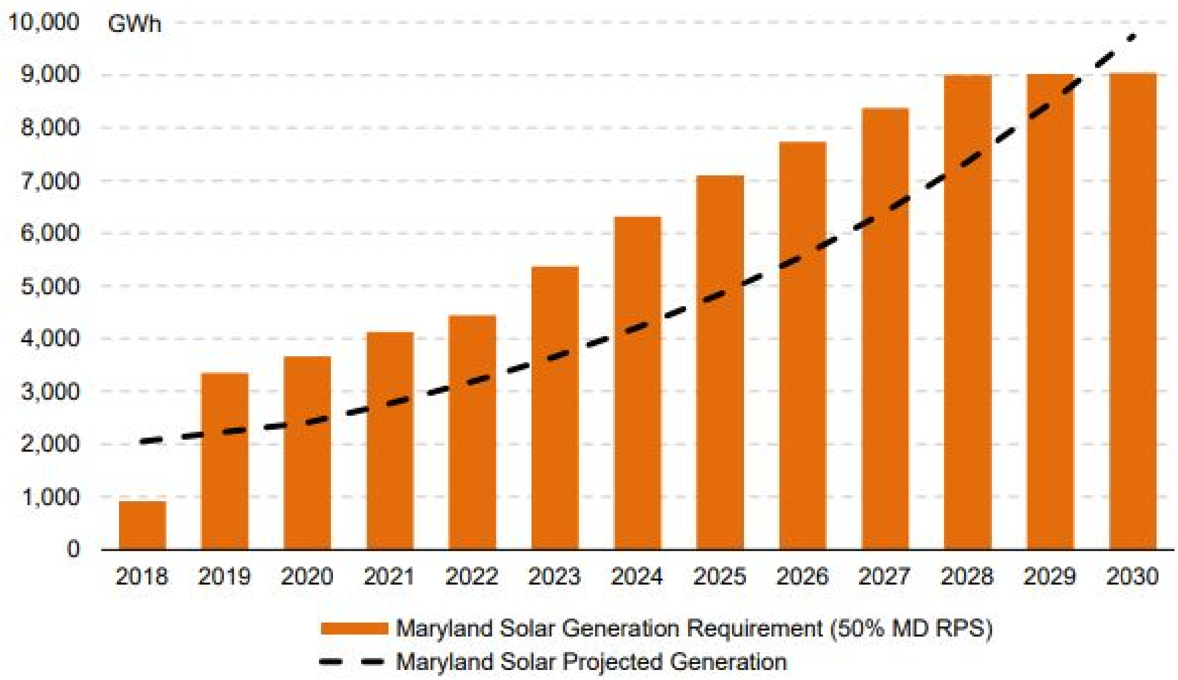
| | Land area - square miles | % of state land area | Solar carve-out share (GWh) |
|---|---|---|---|
| **Baltimore city** | 80.34 | 0.82% | 73.5 |
| **Baltimore County** | 597.6 | 6.07% | 546.4 |
| **Baltimore - city and county combined** | 677.94 | 6.89% | **619.8** |
| **Maryland** | 9,844 | 100.00% | 9,000.0 |

**Population 2018 (US Census)**

| | Population | % of state population | Solar carve-out share (GWh) |
|---|---|---|---|
| **Baltimore city** | 602,495 | 9.97% | 897.4 |
| **Baltimore County** | 828,431 | 13.71% | 1,233.9 |
| **Baltimore - city and county** | 1,430,926 | 23.68% | **2,131.2** |

| | | | |
|---|---|---|---|
| **combined** | | | |
| **Maryland** | 6,042,718 | 100.00% | 9,000.0 |

**Figure 5. 14.5% Solar Carve-out Tier 1 Requirements in Maryland Compared to Projected Maryland Solar Generation, 50% RPS Scenario**




Source: Final Report Concerning the Maryland Renewable Portfolio Standard (Maryland DNR)[3]

## Siting concerns

States and counties across the country are working to address the need to both rapidly grow their solar PV energy capacity while addressing concerns about how and where solar facilities are developed. The potential for rapidly-scaling up the amount of renewable energy produced, as the cost of solar PV panels is rapidly declining, makes utility-scale solar an attractive option, but with environmental trade-offs in the land required for siting, especially in land-constrained regions. The majority of solar power plants are on privately-held land, but are subject to approval by state and local agencies. The permitting process, including environmental review, can take more than three to five years to complete.[4]

[3] "FINAL Report Concerning the Maryland Renewable Portfolio ...." https://dnr.maryland.gov/pprp/Documents/FinalRPSReportDecember2019.pdf. Accessed 8 Mar. 2020.
[4] "Siting, Permitting & Land Use for Utility-Scale Solar | SEIA." https://www.seia.org/initiatives/siting-permitting-land-use-utility-scale-solar.

Estimates of the land required per MW of electricity generated vary from less than 5 up to to 8 acres of land per MW. A Maryland Public Service Commission study found large solar projects in Maryland at the higher end of estimates.[5] The amount ultimately needed for ground mounted utility scale solar will depend on a variety of factors, including future energy use and the portion of solar energy development that will occur on agricultural land. The Governor's Task Force on Renewable Energy Siting estimates the amount of land required may range from 7,500 acres on the low end up to 35,000 acres.

Meanwhile, rooftop solar installations in urban and suburban areas are able to meet a great amount of electricity demand with relatively few adverse environmental impacts. Significant potential exists to continue to expand rooftop solar in residential, community and commercial installations. According to the National Renewable Energy Laboratory (NREL), Maryland has the potential to offset 38.7% of statewide electricity sales with rooftop solar, with a 17.3% potential offset from medium to large buildings.[6] Solar parking canopies are a relatively new option for solar energy generation, with grants available from the Maryland Energy Administration to offset installation costs for businesses and nonprofits.[7]

***Tradeoffs of land use demand for solar***. Designating increasing amounts of land for solar energy development will take land out of other uses. Without siting guidelines and incentives, the majority of future land used for solar energy development is likely to come from agricultural land. Loss of forest cover, wetlands, and ecologically sensitive areas have additionally been identified as undesirable environmental tradeoffs. Loss of forests and wetlands additionally will result in greenhouse gas emissions associated with land clearing, which counteracts the climate mitigation benefits provided by increasing renewable energy.

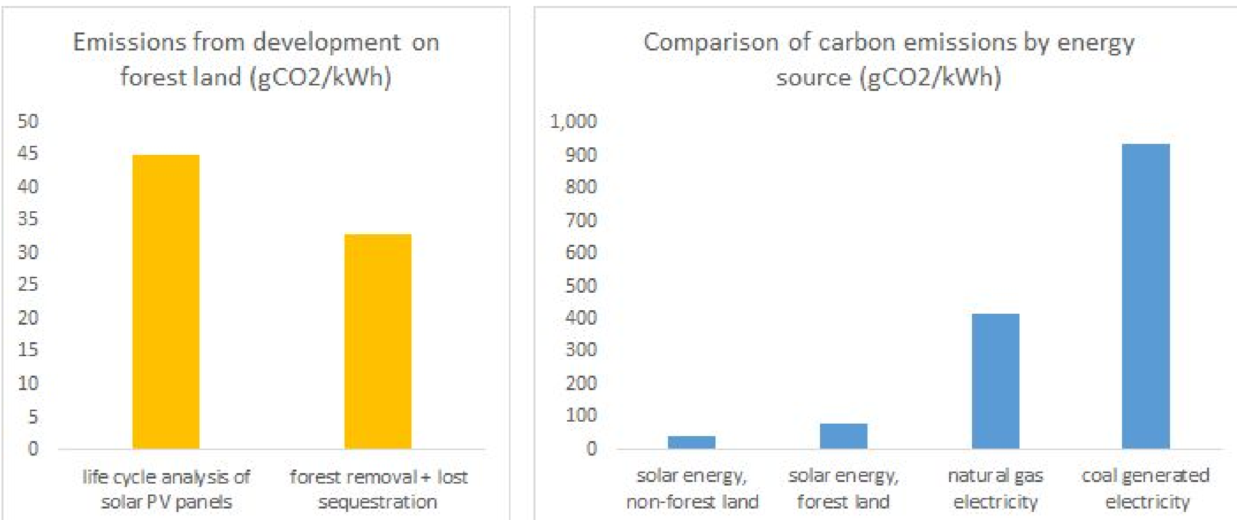
Loss of prime farmland to solar energy development is a key concern related to Maryland's efforts to rapidly scale solar to reach goals of the RPS. According to the USDA National Agricultural Statistics Service, the acreage of cropland harvested in Maryland has decreased by over 280 thousand acres between 1997 and 2017, or 14%.[8] Prime farmland, or the land best suited to agriculture, makes up about 20 percent of Maryland's land, and is found mainly on the Eastern Shore and in north central Maryland. The main source of loss of prime farmland has historically been suburban development, but solar expansion is likely to be a growing cause of farmland loss in the future. The Governor's Task Force on Renewable Energy Development, in its interim report, projects that while half of current solar capacity comes from large scale solar

[5] "Governor's Task Force on Renewable Energy Development and Siting: Interim Report." https://governor.maryland.gov/wp-content/uploads/2019/12/Final-Interim-Report.pdf.
[6] "Rooftop Solar Photovoltaic Technical Potential in the United States: A ...." https://www.nrel.gov/docs/fy16osti/65298.pdf. Accessed 27 May. 2019.
[7] "Parking Lot Solar PV Canopy with EV Charger Grant Program." https://energy.maryland.gov/business/Pages/incentives/PVEVprogram.aspx.
[8] "Maryland Agricultural Statistics - USDA - National Agricultural ...." 5 Nov. 2019, https://www.nass.usda.gov/Statistics_by_State/Maryland/index.php. Accessed 13 Mar. 2020.

arrays, in the future 75% may come from utility-scale solar, and a range of 60-100% of solar development may occur on agricultural lands.[9]

The main source of greenhouse gas emissions associated with solar energy is the manufacture and shipping of the panels, which results in emissions of 45 grams of carbon dioxide for every kWh of energy produced. Clearing forest increases these emissions by an estimated 73% (Figure 6), from the biomass of forest lost, plus lost future carbon sequestration. Compared to fossil-fuel based energy sources, however, solar energy results in fewer carbon dioxide emissions, even when established on forest land. But for Maryland's overall energy-related carbon dioxide emissions to fall as rapidly as possible, limiting loss of forest cover related to solar energy establishment is critical.

**Figure 6. Carbon dioxide emissions associated with solar energy development and conversion of forest land**




***Solar development in the built environment.*** One of the most attractive aspects of solar energy systems is their potential to be co-located with other land uses within cities and suburban areas. This includes residential solar, but also larger-scale community and commercial solar installations on building rooftops and over parking lots in solar canopy installations. Contaminated lands and brownfields, including landfills and former industrial sites offer additional opportunities for solar development.

Encouraging the use of contaminated and degraded lands for solar energy is one of the best ways to minimize the land use impacts of development. Environmentally contaminated lands affected by the improper handling or disposal of hazardous materials or wastes are tracked by the US Environmental Protection Agency (EPA) and state voluntary cleanup programs (VCPs). An

[9] Renewable Energy Task Force - Office of Governor Larry Hogan. Interim Report. https://governor.maryland.gov/energy-task-force/.

NREL analysis, *Solar Development on Contaminated and Disturbed Lands*, found 20 million acres of such lands that could be suitable for the deployment of solar PV and Concentrated Solar Power (CSP) systems.[10] The US EPA RE-Powering America's Land identifies opportunities to site renewable energy on contaminated lands, landfills and mine sites, with 130,000 sites located nationwide. Completed Solar PV projects in Maryland on these sites include Fort Detrick, a Superfund site, and former landfills in Ellicott City, Hagerstown, and Williamsport.[11] Solar energy development on brownfield and closed landfill sites promises new opportunities for making productive use of and generating income from long-abandoned land areas.

In densely populated areas of the country there may be sufficient opportunities on already developed or previously degraded lands to preclude the necessity of converting large areas of rural land for solar. A recent study of opportunities for solar development in California identified sufficient opportunities for photovoltaic (PV) and concentrating solar power (CSP) within the built environment to exceed current statewide electricity demand.[12] Such studies have not yet been conducted at the Baltimore County or Maryland State scale, but would provide valuable information to guide the development of policies for solar energy development. The demonstration of sufficient opportunities for solar energy generation within the built environment could provide a strong alternative to rural land conversion, especially if coupled with financial incentives and regulatory provisions to reduce project costs and ease the permitting process.

***Solar development policies to encourage development in preferred locations.*** There appears to be broad consensus on several principles for solar energy siting, as reflected in the findings of The Governor's Task Force on Renewable Energy Develop and Siting Interim Report, [citations needed]

Ground-mounted solar competes with desirable land uses, for food production and environmental services

- Conversion of prime farmland for solar energy development should be avoided because it removes the best land needed for food production.
- Loss of forest cover and ecologically sensitive lands are undesirable environmental tradeoffs for lands critical to environmental protection and climate mitigation and resilience.

However, solar energy development is an opportunity to put degraded or contaminated lands and underutilized industrial sites to productive use

- Capped landfills, contaminated lands, sites adjacent to wastewater treatment plants and other abandoned sites can be repurposed for solar energy production.

---

[10] "Solar Development on Contaminated and Disturbed Lands - NREL." https://www.nrel.gov/docs/fy14osti/58485.pdf.
[11] "RE-Powering America's Land Initiative: Benefits Matrix, October 2018 - EPA." https://www.epa.gov/sites/production/files/2018-10/documents/benefits_matrix_final_101818_web.pdf.
[12] "Efficient use of land to meet sustainable energy needs | Nature Climate Change 5.4 (2015): 353." 16 Mar. 2015, https://www.nature.com/articles/nclimate2556.

Solar energy development in the built environment does not interfere with productive use of developed lands

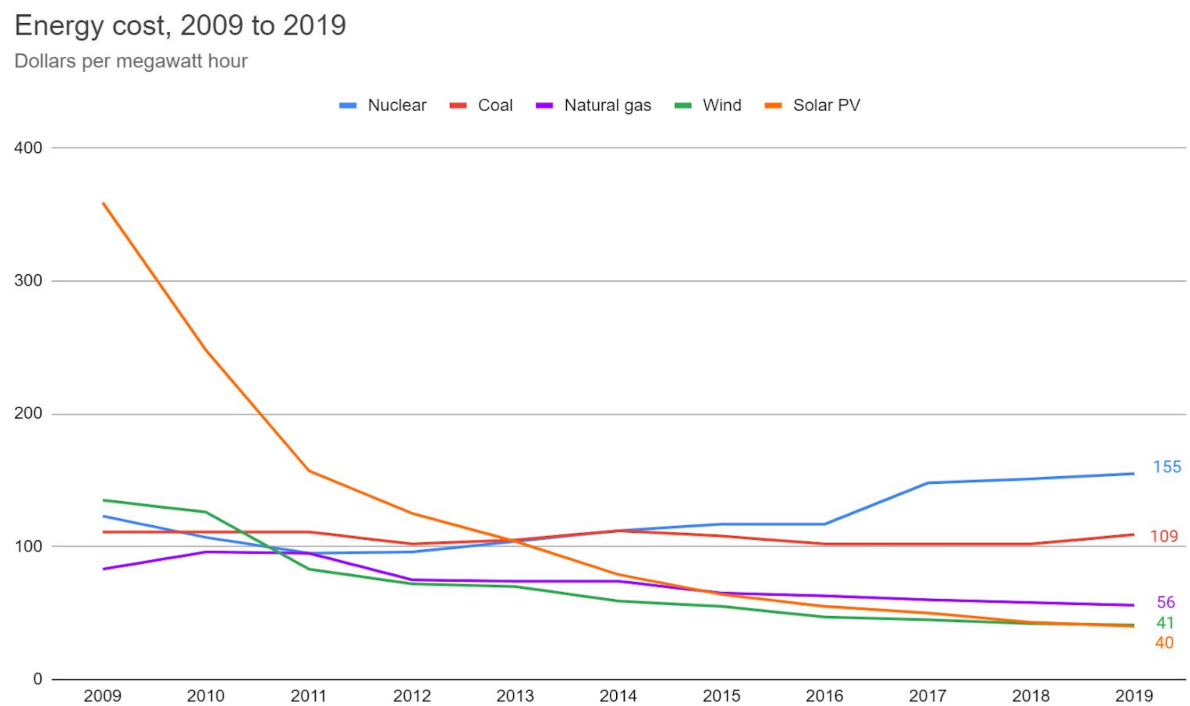
- Solar energy production is compatible with residential, commercial and public building uses - it co-exists with and enhances these property uses
- Solar parking canopies provide benefits including shaded parking, urban heat island reduction, and opportunities for electric vehicle charging

Solar energy development contributes to economic growth and provides opportunities for economic equity

- Solar energy produced through distributed generation with net-metering, including virtual net metering, provides significant economic benefits to homeowners and commercial property owners as well as considerable cost savings for public buildings and services
- Solar energy development is an important and growing source of employment.
- Skilled jobs within or accessible to low to moderate income areas provide significant equity benefits.
- Nonprofit community solar offers significant equity opportunities, when savings or income from net-metering, renewable energy credits (RECs), and investment tax credits (ITCs) are passed on to subscribers.

[NJ and also Massachusetts examples]

**Figure 7. The average cost of utility-scale solar is rapidly declining and is now less expensive than fossil fuels**[13]




Source: Lazard's Levelized Cost of Energy Analysis, 2019

## Solar Development in Maryland, Baltimore County and Baltimore City

According to the PJM, the regional electricity transmission organization for Maryland, Maryland had 1,250 MW capacity in installed solar projects in March 2020.[14] The state ranks 15th in the nation in solar power, and 16th in solar jobs. Maryland's solar capacity is projected to more than double within the next five years.[15] Baltimore County has 98 MW of solar capacity and the city of Baltimore has an additional 15.4 MW, for a total of over 8,400 individual solar installations in the region. Large rooftop solar installations include Amazon's fulfillment facility at Sparrow's Point, General Motors' transmission assembly plant in White Marsh, IKEA's Baltimore location and several other commercial projects such as Target and Macy's locations. At this time, Baltimore County's largest operating utility-scale solar power plant is nearly 3 MW in capacity, while

---

[13] "Renewable energy is getting cheaper and it's going to change ...." 14 May. 2018, https://www.weforum.org/agenda/2018/05/one-simple-chart-shows-why-an-energy-revolution-is-coming-and-who-is-likely-to-come-out-on-top. Accessed 28 Jun. 2019.
[14] "Renewable Generators Registered in GATS - PJM GATS." https://gats.pjm-eis.com/gats2/PublicReports/RenewableGeneratorsRegisteredinGATS. Accessed 14 Mar. 2020.
[15] "Maryland - SEIA." https://www.seia.org/sites/default/files/2019-12/Maryland.pdf. Accessed 26 Feb. 2020.

statewide, the largest facility registered in PJM GATS is a 100MW Great Bay Solar installation in Somerset County.

Most projects for ground-mounted solar within Baltimore County are still in the planning stages. There were a total of 18 applications for BGE's Community Solar Pilot Program in Baltimore County, primarily for ground-mounted solar projects, including a 1MW operating facility in Kingsville, MD. Baltimore County passed solar legislation in June 2017 (Bill 37-17). The bill limited "commercial" solar facilities to ten per council district. The third council district, which has the bulk of the county's farmland, was the first to have ten applications for community solar projects. As of March 2020, fifteen of these projects have had their zoning petitions for solar installations granted, two are pending, and one has been withdrawn.[16] [include table of proposed projects or link to online source]

The Maryland Energy Administration (MEA) and Power Plant Research Program (PPRP) provide maps of existing and proposed solar projects (1+ MW capacity) in Maryland on the Smart DG+ map tool. In addition to the Community Solar Pilot Projects noted above, SmartDG+ maps within Baltimore County ten operational and eleven proposed solar projects, that are a mix of ground-mounted and commercial rooftop installations.[17] Baltimore Gas & Electric (BGE) has initiated a Community Solar Pilot Program within the utility's service area, with 19 registered projects in Baltimore County as of April 2019 (4 projects have been withdrawn).[18]

Because land use is managed by each county in Maryland, there is wide variation as to how solar power plants are regulated. In some counties, they are treated as an industrial use and allowed only in industrial zones as a principal use, while other counties, including Baltimore County, allow them by special exception in agricultural and other zones. This use was not contemplated in most local comprehensive plans, and many local jurisdictions had to scramble to get regulations on the books. Some have gone back to revise regulations to address concerns, particularly about the use of prime soils and forested lands as the first choice for such facilities. The Governor's Task Force on Renewable Energy Development and Siting is expected to provide recommendations for policies and incentives at the statewide and local scale.

## Employment in the Solar Industry

Employment trends in Baltimore County, the Baltimore metro region and Maryland reflect trends in the solar industry nationwide. Baltimore County solar industry employment declined in 2018, while in the Baltimore metro region, employment declined in both 2017 and 2018. Statewide, solar industry employment rebounded 7.5% in 2019, following declines in the two previous years.

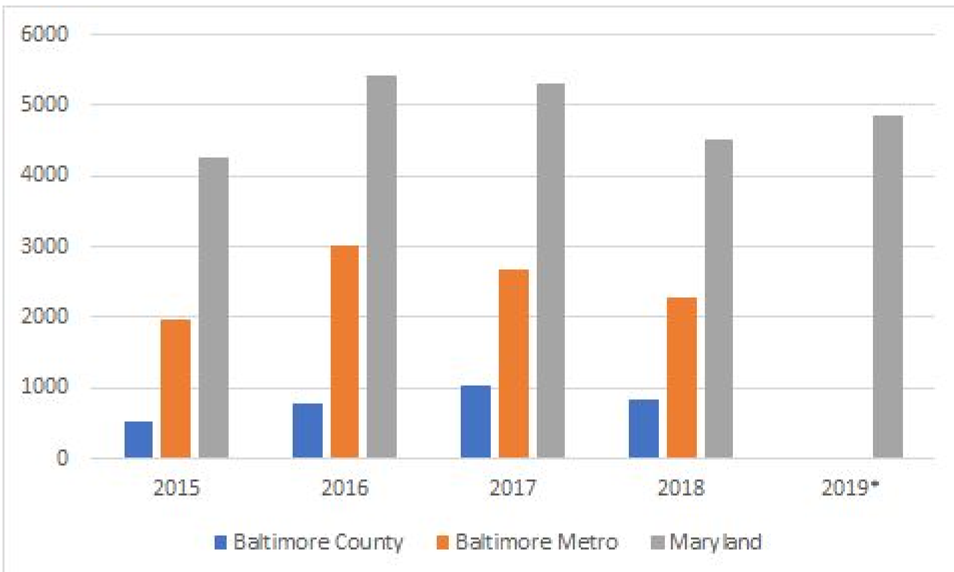
---

[16] "Baltimore County - My Neighborhood." https://myneighborhood.baltimorecountymd.gov/. Accessed 14 Mar. 2020.
[17] "SmartDG+ - Department of Natural Resources - Maryland.gov." http://dnr.maryland.gov/pprp/Pages/smartdg.aspx. Accessed 24 May. 2019.
[18] "BGE Community Solar Pilot Program | Baltimore Gas and Electric ...." https://www.bge.com/SmartEnergy/InnovationTechnology/Pages/BGECommunitySolarPilotProgram.aspx. Accessed 24 May. 2019.

Tariffs on imported solar panels imposed in January 2018 are cited as the main reason for recent employment trends. Nationally, the solar industry employs nearly 250,000 workers, showing a rebound in 2019 of 2.3%, somewhat less than the projected 7% increase in 2018.[19]

Within Maryland, the newly passed Renewable Portfolio Standard is expected to significantly boost solar energy jobs in the state. According to a study by the Maryland Public Service Commission, the new RPS standard is expected to generate 22,563 job-years (a job year is equivalent to one person being employed for one year) over the next 10 years, through the addition of 2.4GW of solar energy generating capacity.[20]

**Figure 8. Solar industry employment, 2015-2019**




*2019 data provided statewide employment figures only

## Equity and Opportunity

The rapid growth in solar energy provides an opportunity to ensure that all people have access to affordable, renewable energy. Low income communities have borne many of the adverse impacts of energy production in the past, for example, from increased exposure to pollution related to energy production and low rates of employment in lucrative energy-related fields.

***Access to affordable energy***. Solar energy provides opportunities to incorporate equity concerns into placement of solar energy resources and equitable distribution of solar energy economic benefits. Maryland's Community Solar Pilot Program and aggregate net energy metering (ANEM)

[19] The Solar Foundation, National Solar Jobs Census 2019, February 2020, available at http://www.SolarJobsCensus.org.

[20] "Benefits and Costs of Utility Scale and Behind the Meter Solar Resources in Maryland." Daymark Energy Advisors. 2 Nov. 2018, https://cleantechnica.com/files/2018/11/MDVoSReportFinal11-2-2018.pdf. Accessed 30 Jun. 2019.

policies increase the affordability of energy by allowing customers to access the financial benefits of excess generation credits.[21]

However, community solar may not be providing access to many low and moderate income customers. According to a survey by the Smart Electric Power Alliance, only 44% of community solar programs have low and moderate income (LMI) subscribers. According to SEPA, to expand participation to LMI customers, the subscription price for solar energy must be equal or lower than the prevailing electricity cost. NREL has found, however, that utility-supplied green power products, which typically supply energy from both solar and wind, have premium pricing, costing the average home $18/month over standard pricing.[22,23]

***Employment opportunities*** Solar energy development is also providing rapid growth in green energy jobs in the US. Planning for equity and opportunity in solar site planning, by prioritizing inclusion of lower income and urban communities as well as sites accessible by public transportation in solar project plans could much needed employment opportunities. Locating projects within IRS Opportunity Zones, which are economically-distressed communities where new investments may be eligible for preferential tax treatment, is another potential way to generate benefits for lower income communities. Community solar projects can increase access to solar energy and energy cost savings to all residents, including those who are not homeowners - an important equity consideration.

***Policies and incentives to guide solar siting*** Twenty-nine states and the District of Columbia have renewable portfolio standards that provide targets for electricity generation from renewable sources.[24] Policies and regulations vary widely across states. Massachusetts and New Jersey have been lauded for their policies, rebates and incentives that guide solar energy development towards preferred sites. Solar Power Rocks is an organization that provides annual rankings of states in terms of solar energy policies and in 2019 piloted an evaluation of policies for low income families.[25]

## Results and Discussion

Our analysis found nearly 32,000 acres of optimal and preferred sites for solar energy development in Baltimore County and the city of Baltimore. Of this total, 86% is within the built environment, either on rooftops (70%) or in large parking lots greater than 5 acres in size (15.8%).

---

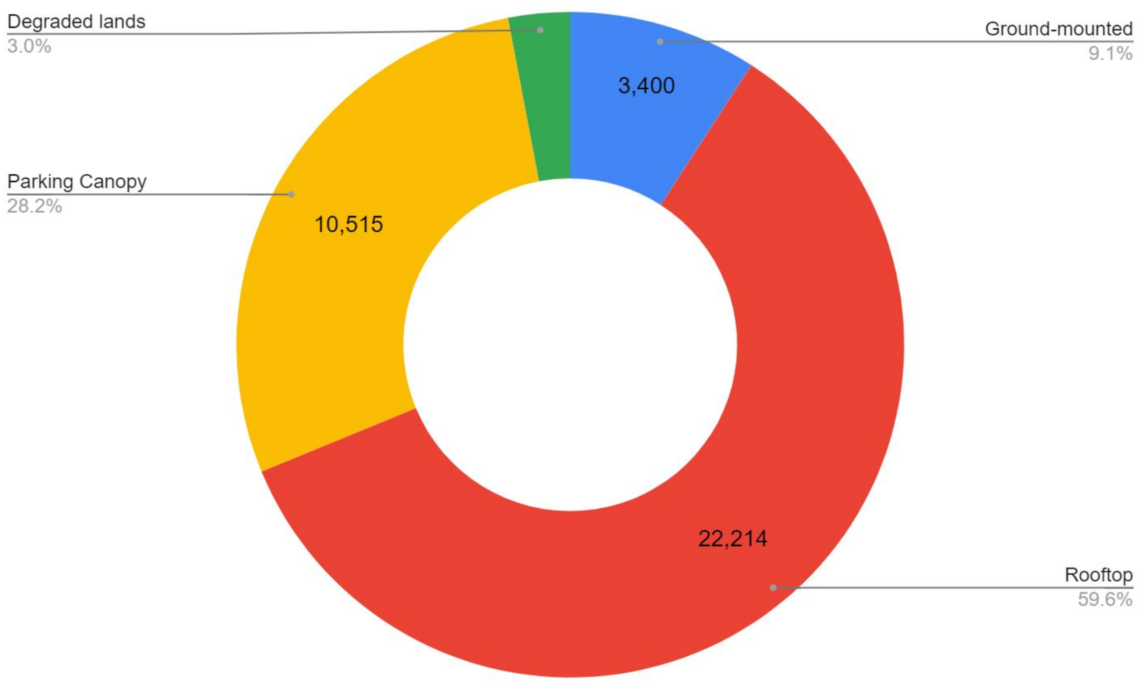
[21] "2018 MD PSC Report on the Status of Net Energy Metering." 1 Sep. 2018, https://www.psc.state.md.us/wp-content/uploads/FINAL-2018-Net-Metering-Report.pdf. Accessed 26 Feb. 2020.
[22] "Status and Trends in the U.S. Voluntary Green Power Market ...." 5 Oct. 2016, https://www.nrel.gov/docs/fy17osti/67147.pdf. Accessed 30 Apr. 2020.
[23] "Green Power Pricing | Green Power Partnership | US EPA." 15 Apr. 2019, https://www.epa.gov/greenpower/green-power-pricing. Accessed 30 Apr. 2020.
[24] "State Renewable Portfolio Standards and Goals - Ncsl." 31 Dec. 2019, https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx. Accessed 17 Mar. 2020.
[25] "Solar Power Rocks." https://www.solarpowerrocks.com/. Accessed 17 Mar. 2020.

An additional 866 acres (3.5%) fall within degraded lands. We estimate a total of 8,719 GWh/yr of electricity could be generated from these sites, demonstrating that extensive opportunities exist within optimal and preferred sites to contribute proportionally to Maryland's RPS goals.

**Table 2. Potential energy generation from preferred and optimal sites**

| **Energy generation** | | |
|---|---|---|
| | **Acres** | **Energy (GWh/year)** |
| **Preferred ground mounted** | 3,400 | 2,242 |
| **Rooftop** | 22,214 | 7,608 |
| **Parking canopy** | 5,004 | 1,669 |
| **Degraded lands** | 1,116 | 601 |
| **Total** | | 12,120 |

**Figure 9. Total optimal and preferred sites for solar energy development in Baltimore County and City (Acres)**




## Optimal solar sites on degraded lands

Baltimore County offers over 1100 acres of degraded lands with potential for solar energy development. These include closed landfills, Hernwood and Parkton, the decommissioned Pikesville Reservoir, and land at the wastewater treatment plant. Similar locations have been developed for solar throughout Maryland. In addition, we have identified 182 acres of underutilized industrial sites as well as 570 acres of brownfield sites. Some of these locations could potentially be used for solar energy development, either as an interim land use, or as part of cleanup or redevelopment projects. We did not assess degraded lands opportunities within Baltimore city, as most properties in the Voluntary Cleanup Program (VCP) are on small sites, and underutilized

## Rooftop solar

Rooftop solar offers the largest opportunity, at over 22,000 acres, with 7,809 acres in the city of Baltimore and 14,405 acres in Baltimore County. According to PJM GATS, Baltimore city has 15.4 MW of installed solar capacity, or 26 watts per capita, using 2018 US Census population estimates. In comparison, Washington DC has 82 MW of installed solar capacity, or 117 watts per capita, a rate over quadruple that of Baltimore.

Across Baltimore City and County, residential rooftops make up the majority of rooftop area, with nearly 58% in Baltimore County and over 60% in Baltimore City. Commercial and industrial sites offer the potential for large installations, some of which rival the size of utility-scale solar. Taking advantage of roof space on large public buildings offers a large opportunity for city and county governments to contribute towards solar energy goals, with over 750 acres of rooftop opportunity on Baltimore county public schools, firehouses and other county buildings.

We estimate potential energy production from Baltimore city rooftops as 4,207 GWh/year, and for Baltimore County, 7,760 GWh/year, although this overestimates potential energy generation as we did not take into account roof angle or shading by tree canopy into account. Previous estimates of solar energy potential for Baltimore rooftop solar are available from Google Project Sunroof (2,800 GWh/year)[26] and NREL (Gagnon et al.; 2,549 GWh/year).[27] Because neither of these studies included all Baltimore County rooftops, we assume that the average of the two estimates, or 2,675 GWh/year, or 64% of the energy potential we estited from rooftop area alone. We extend this estimate to Baltimore County, to estimate energy generation capacity at 4,933 GWh/year (64% of 7,760 GWh/year calculated from all rooftop area).

**Figure 10. Rooftop area for Baltimore County and City (Acres)**

[26] "Project Sunroof - Data Explorer - Google." https://www.google.com/get/sunroof/data-explorer/. Accessed 8 Mar. 2020.
[27] "Rooftop Solar Photovoltaic Technical Potential in the United …." https://www.nrel.gov/docs/fy16osti/65298.pdf. Accessed 8 Mar. 2020.

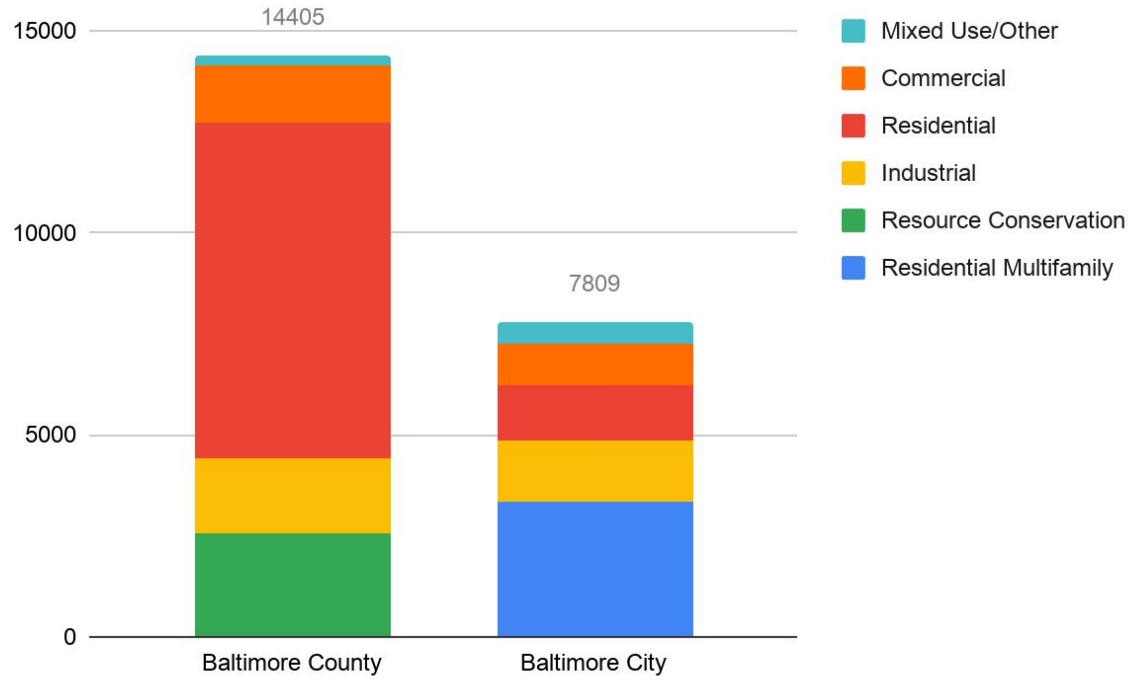



**Table 3. Baltimore County potential rooftop solar area**

| **Baltimore County Rooftop** | |
|---|---|
| **Zoning Group** | **Acres** |
| Commercial | 1,436 |
| Industrial | 1,870 |
| Mixed Use | 218 |
| Residential | 8,298 |
| Residential/Multifamily | 23 |
| Resource Conservation | 2,557 |
| Resource Conservation/Mixed Use | 3 |
| Total | 14,405 |

**Table 4. Baltimore city potential rooftop solar area**

| **Baltimore City Rooftop** | |
|---|---|
| **Zoning Group** | **Acres** |
| Commercial | 1,018 |
| Educational Campus | 130 |

| | |
|---|---|
| Hospital Campus Zoning District | 110 |
| Industrial | 1,522 |
| Mixed Use | 270 |
| Open Space and Environmental Districts | 59 |
| Residential | 1347 |
| Residential Multifamily | 3353 |
| Sum | 7,809 |

**Table 5. Rooftop solar development area on public buildings in Baltimore County**

| Baltimore County Public Buildings | Acres |
|---|---|
| County public schools | 297 |
| County-owned buildings (other) | 442 |
| Firehouses | 14 |
| Total | 753 |

## Parking canopy opportunities

Parking lots offer over 28% of the optimal solar energy development area identified in Baltimore County and City. The estimate was restricted to lots >1 acre in size and parking garages with an open top deck. While parking canopies are among the most expensive types of solar installations, they offer desirable amenities including shaded parking spaces and potential to provide charging for electric vehicles.

Solar panels can generate approximately 2 kW per parking space.[28] Assuming 150 parking spaces per acre, 300 kW can be generated per acre of parking lot.[29] With 10,515 acres of parking lots over 1 acre in size, Baltimore County and City have the potential for 3,507 GWh/yr of solar generation from parking canopy solar.

**Table 6. Solar energy development area for parking canopies (acres)**

| | Baltimore County | Baltimore City | Total |
|---|---|---|---|
| Parking lots >1 acre | 6,898 | 3,578 | 10,476 |
| Garages | 6 | 33 | 39 |
| | 6,904 | 3,611 | 10,515 |

[28] Shoup, Donald. *Parking and the City*. Routledge, 2018.
[29] "Estimating the Number of Parking Spaces per Acre." https://ag.tennessee.edu/cpa/Information%20Sheets/CPA%20222.pdf. Accessed 7 Mar. 2020.

**Preferred ground-mounted solar sites**

Analysis of ground-mounted solar development opportunities identified 3,400 acres of land parcels suitable for utility-scale solar (1MW or greater capacity) that would offer the fewest environmental tradeoffs. Parcels identified as preferred sites passed initial screens for legal and technical feasibility, and were among the highest ranking sites for additional criteria including low portions of land occupied by tree canopy and prime farmland.  A significant number of sites identified include active farms (horses or other grazing animals, with open land in pasture) as well as large residential properties. It is likely that only a small portion of these parcels would be available for solar energy development.

Preferred sites for ground-mounted solar represented just 0.8% of Baltimore County's land area, highlighting the challenge of identifying lands with the fewest environmental tradeoffs.
Many additional opportunities exist for solar energy as a portion of the use of these lands, with on-farm solar used for only a portion of the land. Rooftop opportunities were also assessed for all rural lands.

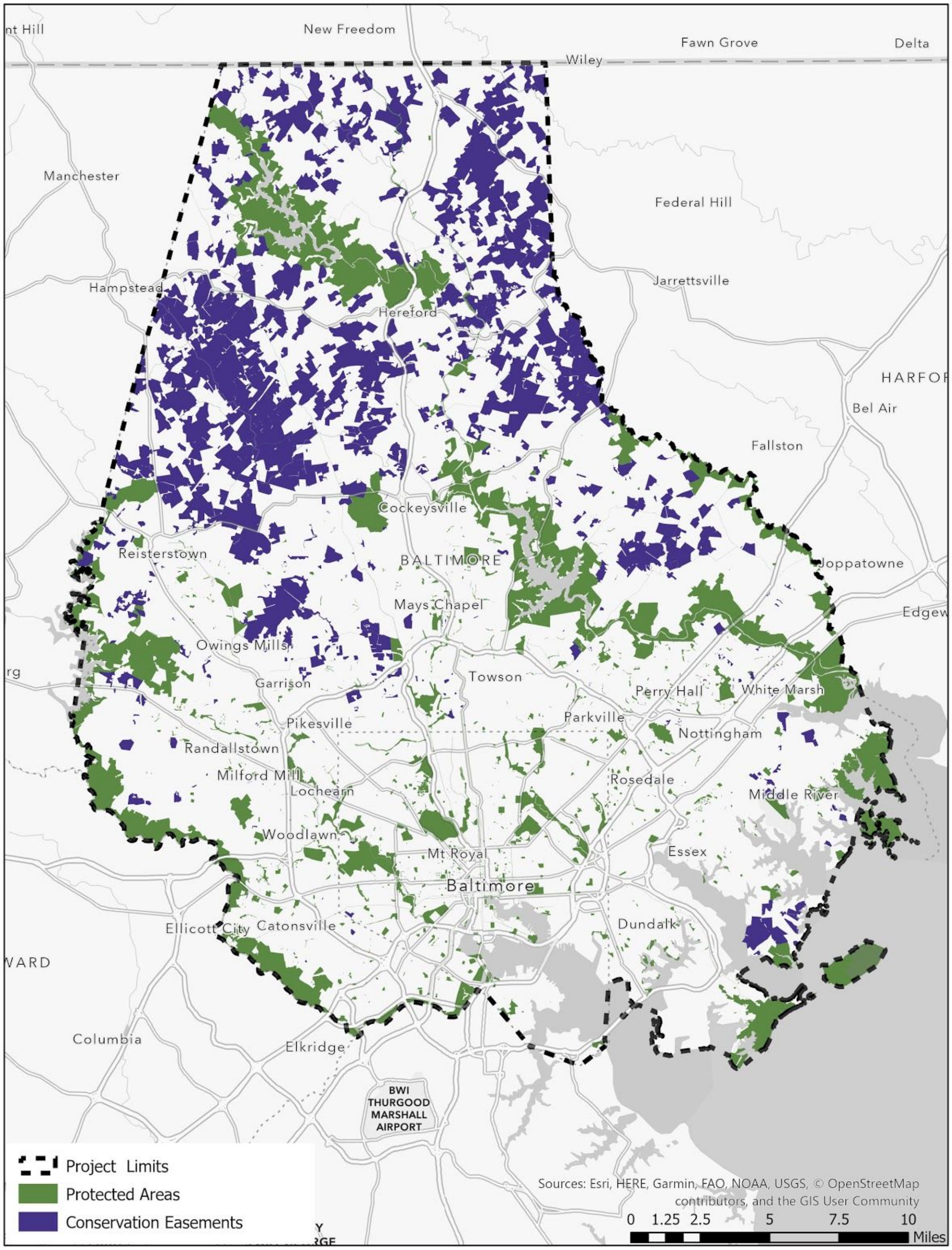
We identified only 20 acres of ground mounted solar opportunities in low and moderate income areas or IRS opportunity zones, as well as 76 acres of large rooftop opportunities. Because these tracts in Baltimore County and city area largely in urban and close-in suburban areas, the primary opportunities in these areas are likely to be for rooftop solar, including residential, community and commercial opportunities.

# Conclusions

Maryland's new Renewable Portfolio Standard creates strong incentives to quickly ramp up solar energy development to meet requirements to generate 50% of electricity from renewable energy with 14.5%. Key benefits of solar energy development include flexibility to install solar PV panels in a variety of environments and settings from residential home installations to utility-scale deployments. The potential to co-locate solar energy facilities with other land uses would enable both the re-use of long abandoned degraded or contaminated lands as well as using commercial, multi-family residential and governmental facilities to meet renewable energy goals without competing with alternate land uses or generating adverse environmental impacts. Community solar and prioritizing development on desirable sites within low- and moderate-income areas can increase access to energy savings as well as provide job opportunities. Finally, quantifying and mapping both potential and optimal solar sites across Baltimore County can ensure that sufficient solar energy capacity can be developed that provides the desired benefits to the region.

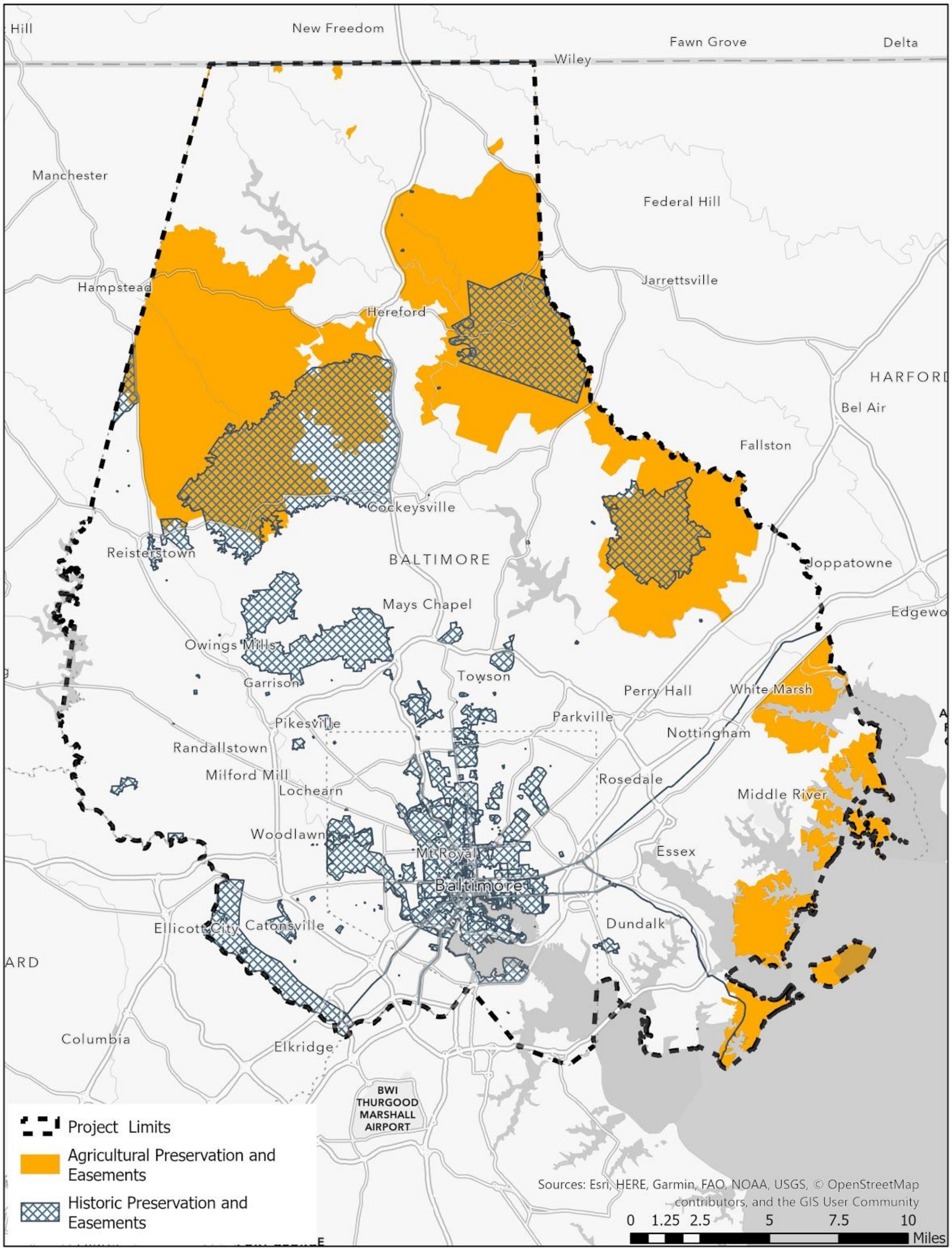
# Appendix A. Maps

### Map 1. Protected areas and conservation easements



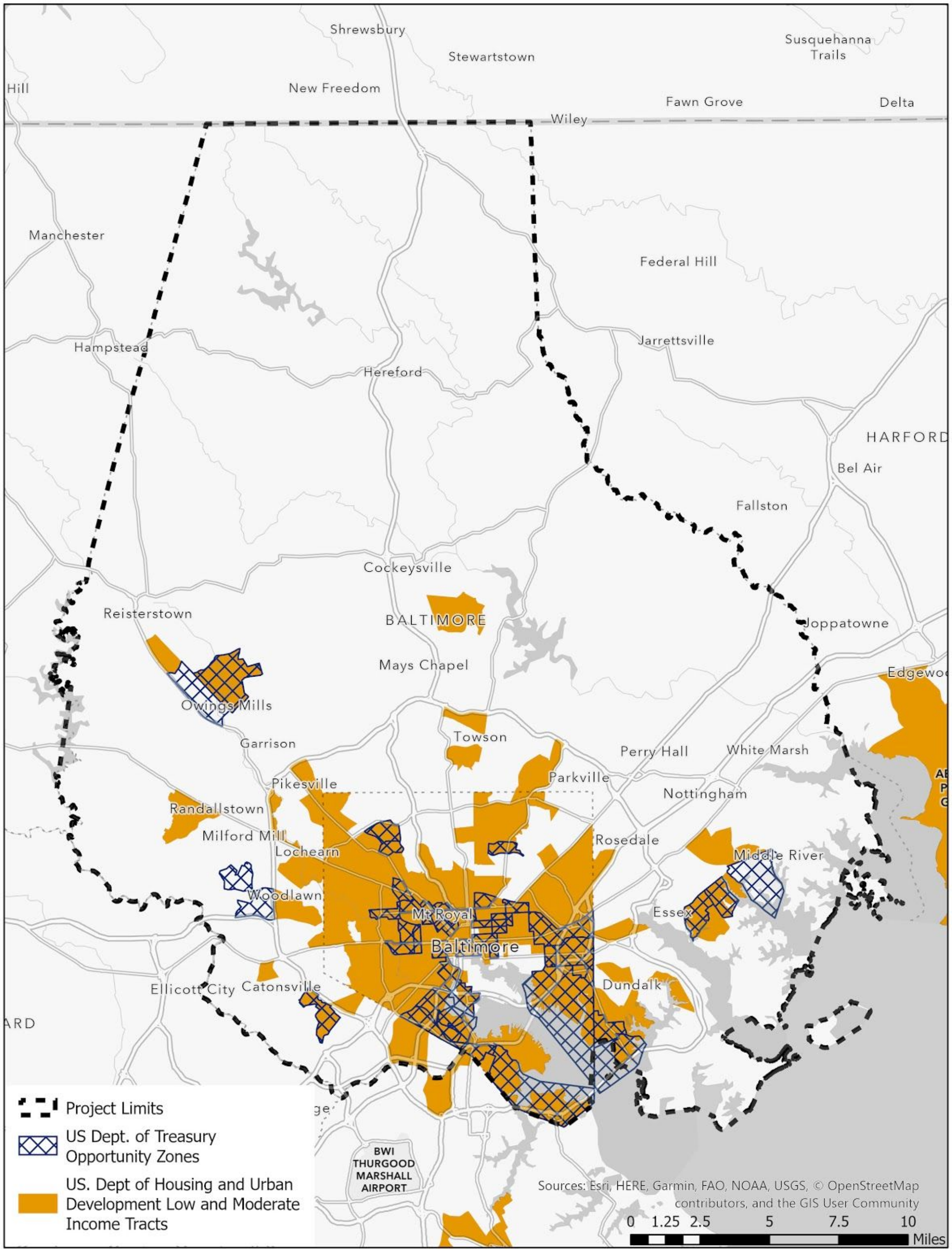

Data: Federal, state and local protected areas, State Scenic Rivers, State Scenic Byways, publicly managed conservation lands, Maryland Environmental Trust Easements, other conservation easements Sources: Maryland Department of Natural Resources (DNR), Chesapeake Conservation Partnership

**Map 2. Agricultural and historic preservation and easement areas**



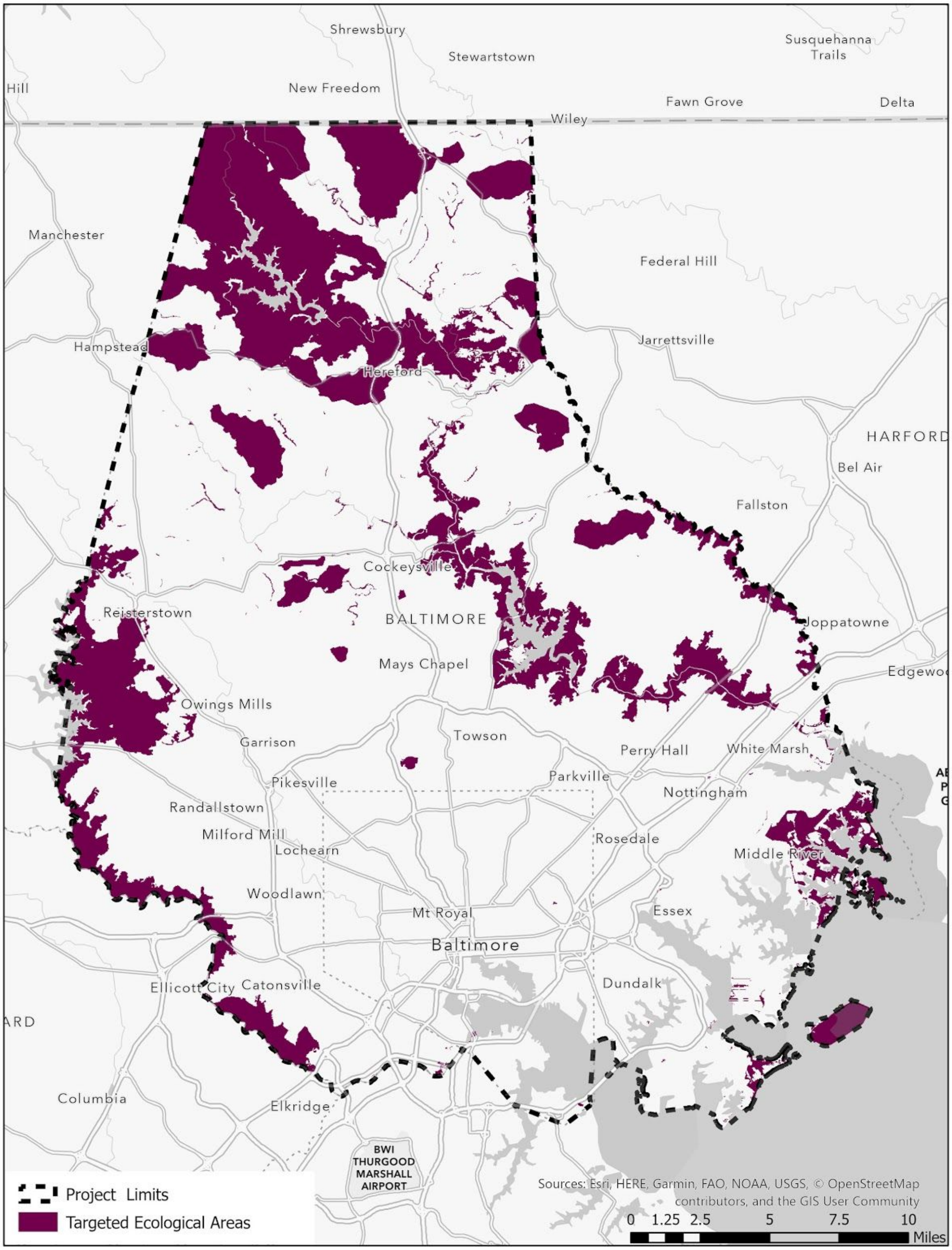

Data: Maryland Agricultural Land Preservation Foundation (MALPF) easements, Rural Legacy Areas, National Register of Historic Places: Historic Districts, National Register of Historic Places, National Historic and Scenic Trails, State Heritage Areas, National Historic Landmarks; Sources: Maryland DNR, Chesapeake Conservation Partnership

**Map 3. Equity criteria: low and moderate income areas**




Sources: US Department of Treasury, IRS; US Department of Housing and Urban Development

**Map 4. Environmental criteria: Targeted Ecological Areas (TEAs)**

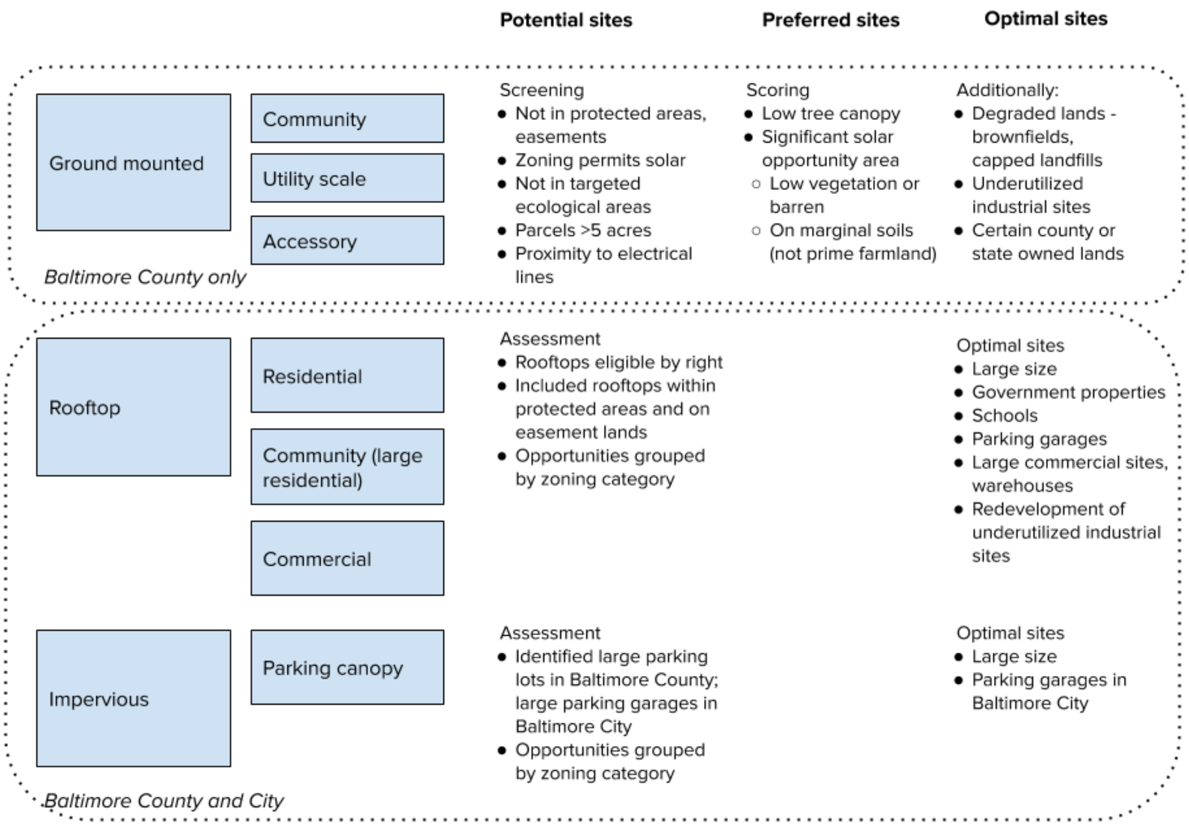



Source: Maryland Department of Natural Resources

# Appendix B. Methods

This study followed a stepwise approach in analyzing opportunities for solar energy development in Baltimore County and City, with the overall approach provided in Figure 1, and additional details provided in Figure 6.

**Figure 6. Methods workflow for identification of potential, preferred, and optimal solar sites**




First, potential solar sites were identified by identifying parcels that passed initial screening, removing lands where zoning would not permit solar and assessing proximity to the electrical grid. Next, sites were scored according to environmental, equity and efficiency criteria, to determine high scoring sites with sufficient solar opportunity air. Additionally, degraded lands were considered for solar development potential.

GIS data for this project was acquired from a variety of reliable sources; notably Baltimore City and County data portals, as well as from the Maryland Department of Planning, for parcel data. The core analysis for solar suitability determination involved reviewing all parcels in Baltimore City and County, and selectively removing them based on characteristics that would preclude solar development, and in later steps, less preferable. Due to differences in data availability, not all of the methods utilized in Baltimore County translated to Baltimore City. The best possible alternatives and solutions were considered to determine viable suitable solar siting in Baltimore City.

**Identification of preferred sites for ground-mounted solar**

We identified opportunities for ground-mounted solar in Baltimore County only. The analysis began with a screening process to identify parcels where solar energy development would be legally and technically feasible. We reviewed solar zoning regulations, removing parcels that where ground-mounted solar panels would not be permitted. Next, we screened out protected local, state, and federal lands, as well as conservation, agricultural and historic easements. Parcels less than 5 acres in size were not considered to ensure a minimum energy generation capacity of approximately 1 MW.

Next, we assessed remaining parcels for suitability based on environmental data including tree canopy cover and presence of prime agricultural soils. land cover was analyzed within the remaining parcels using Chesapeake Conservancy's high-resolution (1m) Chesapeake Bay land cover dataset to document the vegetation coverage of each parcel. From the land cover data, total 'Solar Opportunity Area' (SOA) was calculated, considering the following land cover types most suitable for placement of solar PV panels: herbaceous vegetation, shrubland, and barren land. The area in structures (homes, commercial buildings, etc.), impervious surface such as parking lots, and tree canopy was also determined for each parcel. A ranking system with values of 1-5 was calculated based on 20% thresholds for tree canopy and SOA, with a higher rank indicating parcels more suited to solar development.

For example, a site containing 25% tree canopy was assigned a value of 4, whereas a 25% SOA value was assigned a 2. Those two land cover characteristics were assigned inverse rankings as as site with more trees would be less suitable for development. Conversely, parcels with a higher portion of SOA contain more land was already cleared of trees, reducing the environmental impacts of solar panel installation.

Next, parcels were assessed for proximity to existing electrical grid resources based on datasets developed for the Smart DG+ website application, provided by ERM and the Maryland Power Plant Research Program. Sites remote from the electrical grid were removed from further analysis.

Next, parcels were assessed for the presence of prime farmland soils, using 10m gSSURGO data. Soils described as 'prime farmland' or 'farmland of statewide importance' were considered the lease suitable for solar energy development and ranked accordingly. For example, parcels with the highest proportion of prime farmland were ranked zero, while parcels with no prime farmland were given a rank of 4.

**Equity analysis of low and moderate income tracts**

Using data from the Department of Housing and Urban Development on low and moderate income areas, and from the US Department of Treasury on opportunity zones, parcels were given a rank point if they intersected either dataset. Those datasets were used as proxies for equity in solar development.

By totalling the ranks for each factor across the remaining parcels, a tiered scheme of most-to-least preferred solar parcels can be sorted and displayed to easily distinguish between differently ranked opportunities. The highest value was 14, where a parcel had extremely low tree cover, extremely high SOA, and no valuable soils. Based on a review of parcels and their values, all parcels with a value of 10 or higher were selected as ‘preferred’ solar opportunities. The final step for the preferred data was to determine if the opportunity the parcel presented was more likely a ground-mounted solar construction project or a rooftop or parking canopy, based on the parcel’s portion in impervious surface. From the remaining parcels, a threshold of 20% or less impervious surface was used to categorize a parcel as ‘likely ground mounted,’ where the remaining were ‘likely rooftop/canopy solar.’ Some small manual adjustments were made based on parcels with a high area in structures they outweighed what would otherwise be a high impervious value as well (shopping mall/big box store).

**Identification of degraded lands and other opportunity sites**

Finally, degraded lands were considered, using data from Maryland Department of the Environment’s Voluntary Cleanup Program and data from the Utility-Scale Solar Energy Coalition’s analysis for solar potential on Maryland’s contaminated lands. These sites are considered optimal for solar development from the analysis, though more study will be necessary at the located sites to determine the validity and feasibility of solar. This is especially true in Baltimore City, where many contaminated and environmentally degraded lands have obstructions such as railroad tracks, that would reduce feasibility for development. This analysis was intended to be a first step in determining possible best suited solar locations, and any specific site may require more scrutiny to determine suitability.

Other GIS analysis involved using data from the Baltimore County and Baltimore City data portals to determine structure footprint area, with specific breakouts for public schools and for parking garages. Within Baltimore County, landfills, the wastewater treatment plant, and fire department facilities were also broken out specifically. Using data provided by the localities, and with results from the process above, under utilized industrial opportunities were also identified.

**Rooftop analysis**

Rooftop area was calculated as the area classified as structures in Chesapeake Conservancy’s 2013-14 land cover classification for the Chesapeake Bay Watershed.

We used a formula provided by the US EPA Green Power Partnership, to calculate annual PV solar system output as a function of the equation $E = A * r * H * PR$, in which $A$ = Total solar panel Area ($m2$); $r$ = Solar panel efficiency (%); $H$ = Annual average solar radiation on tilted panels (shadings not included); $PR$ = Performance ratio, coefficient for losses (range between 0.5 and

0.9); and E = Energy (kWh)[30]. For annual average solar radiation, we used an assumption from Google Project Sunroof of the 75% of the maximum annual sun for Baltimore, MD of 1,032 kWh/m2/year.

In addition, data obtained from Google Project Sunroof provided estimates of the percentage of rooftops suitable for solar development and the potential energy generation. This analysis was available for Baltimore City only, as only partial coverage was available for Baltimore County.[31]

[30] "Green Power Equivalency Calculator - Calculations and ... - EPA." https://www.epa.gov/greenpower/green-power-equivalency-calculator-calculations-and-references. Accessed 8 Mar. 2020.
[31] "Project Sunroof - Google." https://www.google.com/get/sunroof. Accessed 7 Mar. 2020.